

In-situ Heat Flow Measurements in the Maria outside the Procellarum KREEP Terrane

S. Nagihara, Texas Tech University
W. S. Kiefer, Lunar and Planetary Institute
K. Zacny, Honeybee Robotics

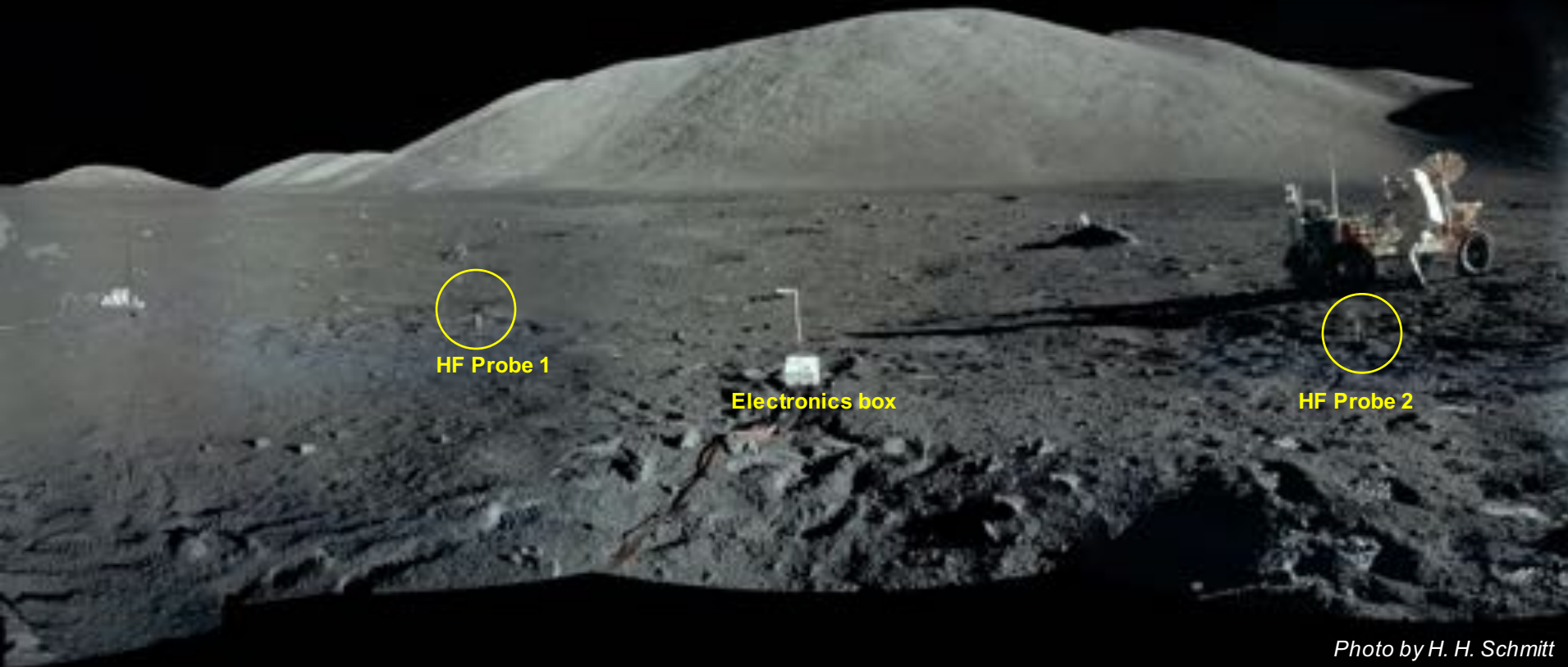


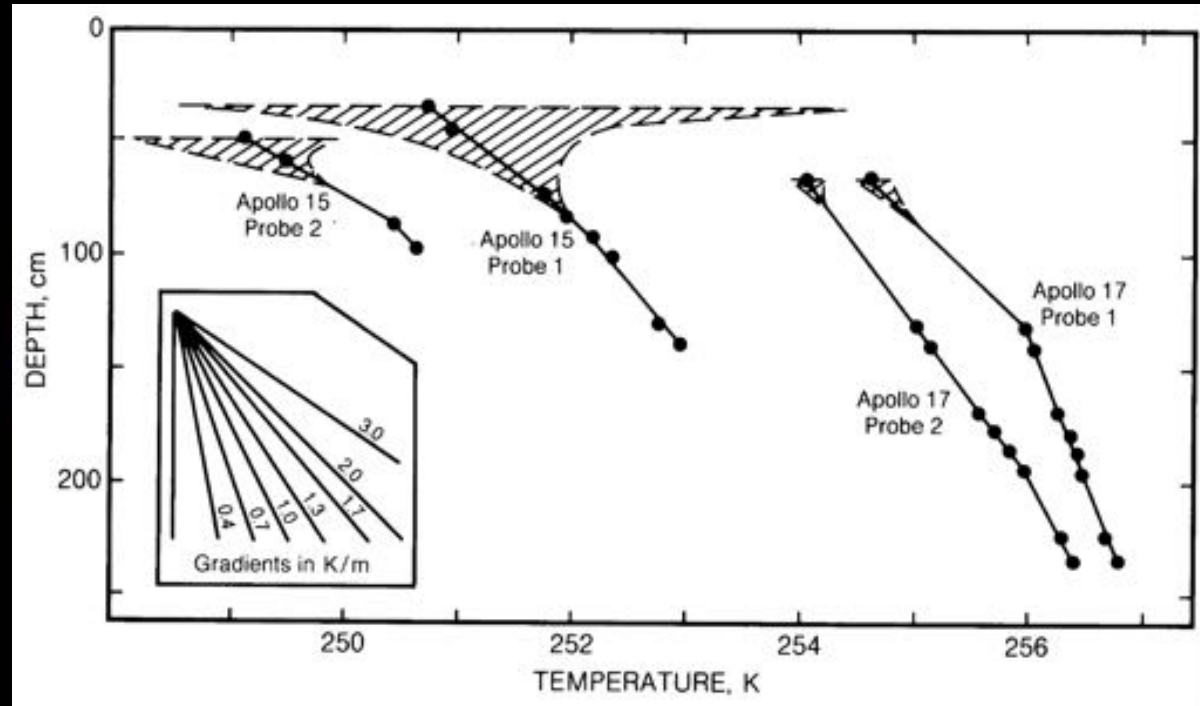
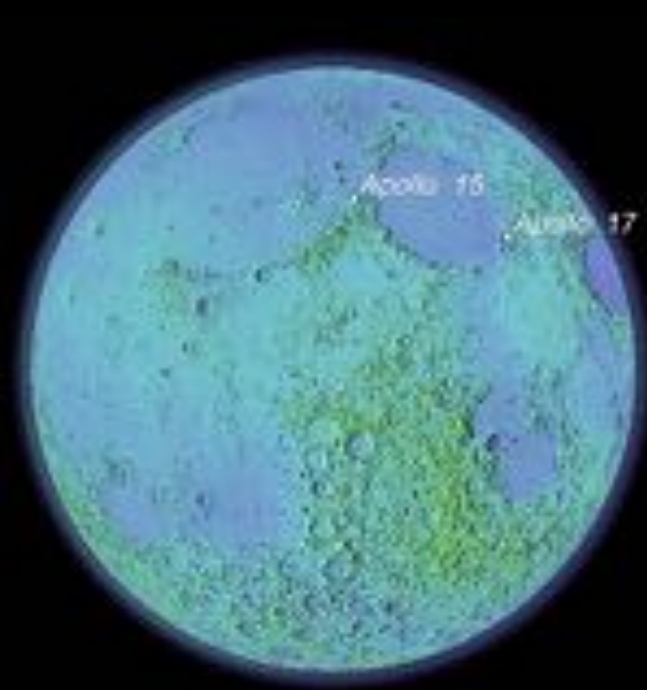
Photo by H. H. Schmitt

heat flow = geothermal gradient x thermal conductivity

Apollo 15 Site: 21 mW/m²

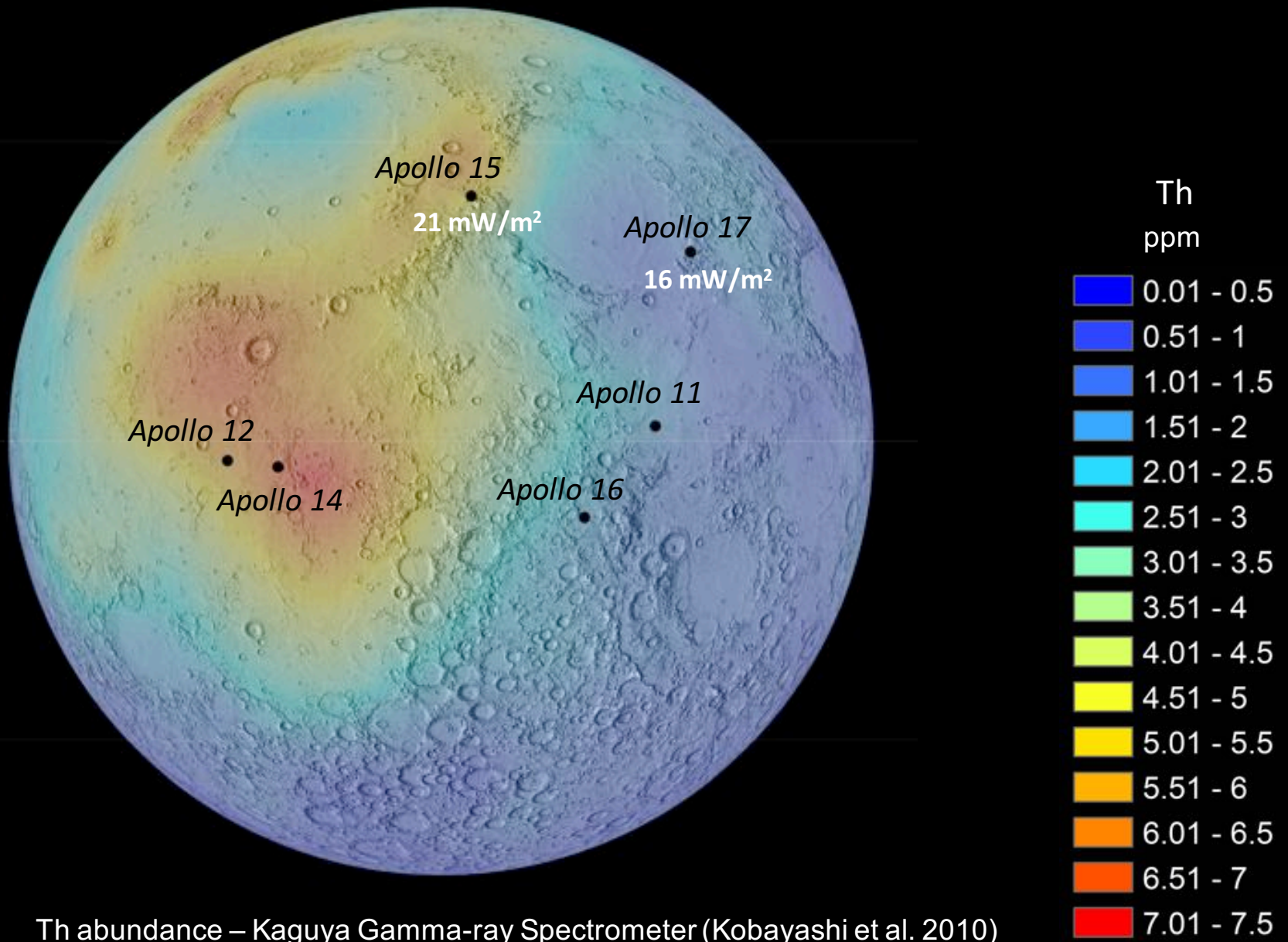
Apollo 17 Site: 16 mW/m²

Geothermal Gradient

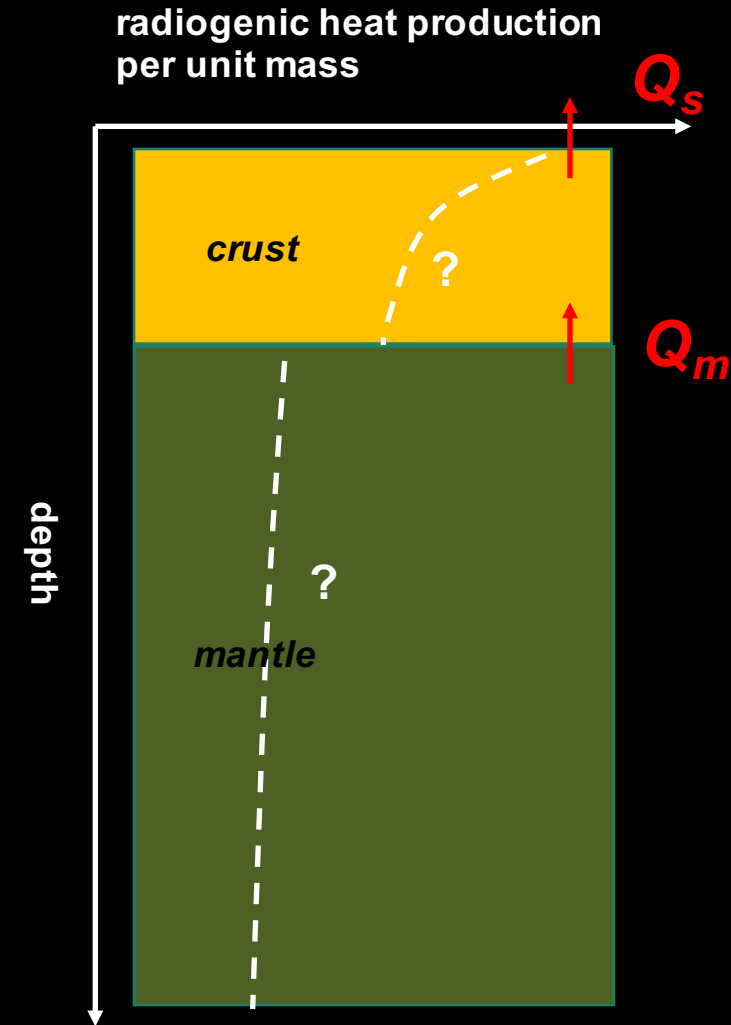
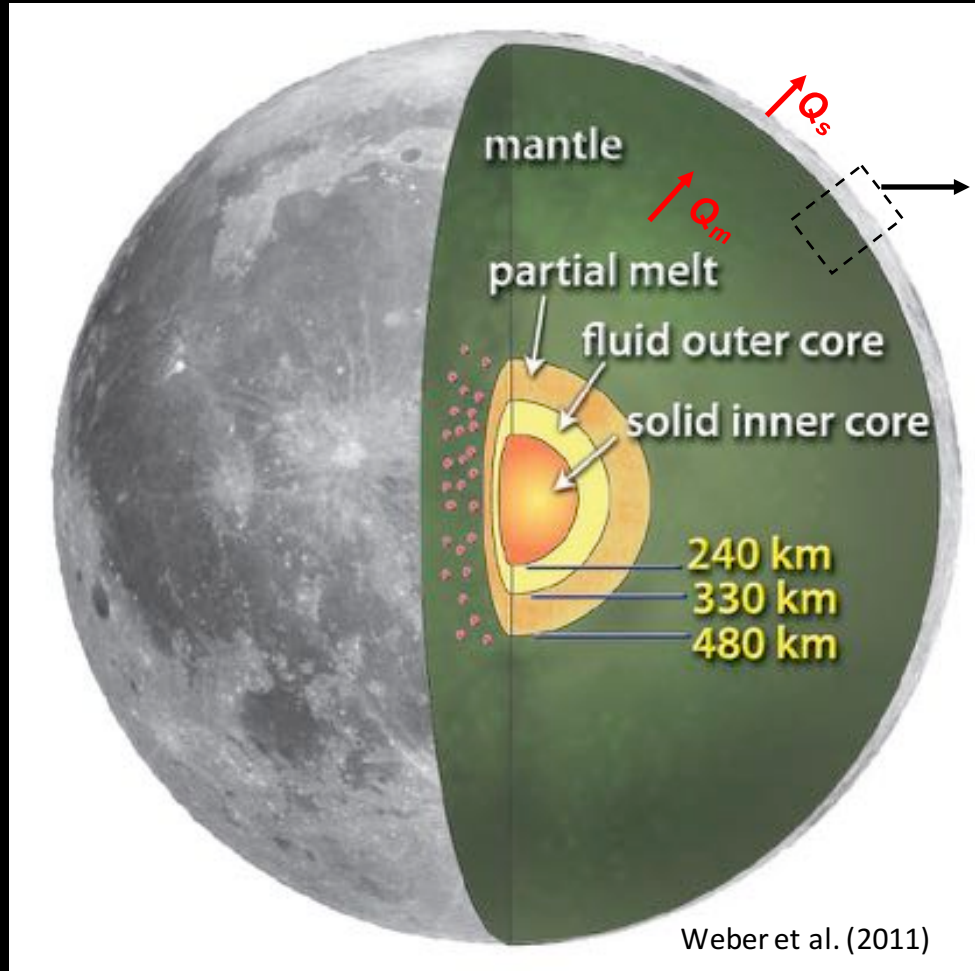


Vaniman et al. (1991)

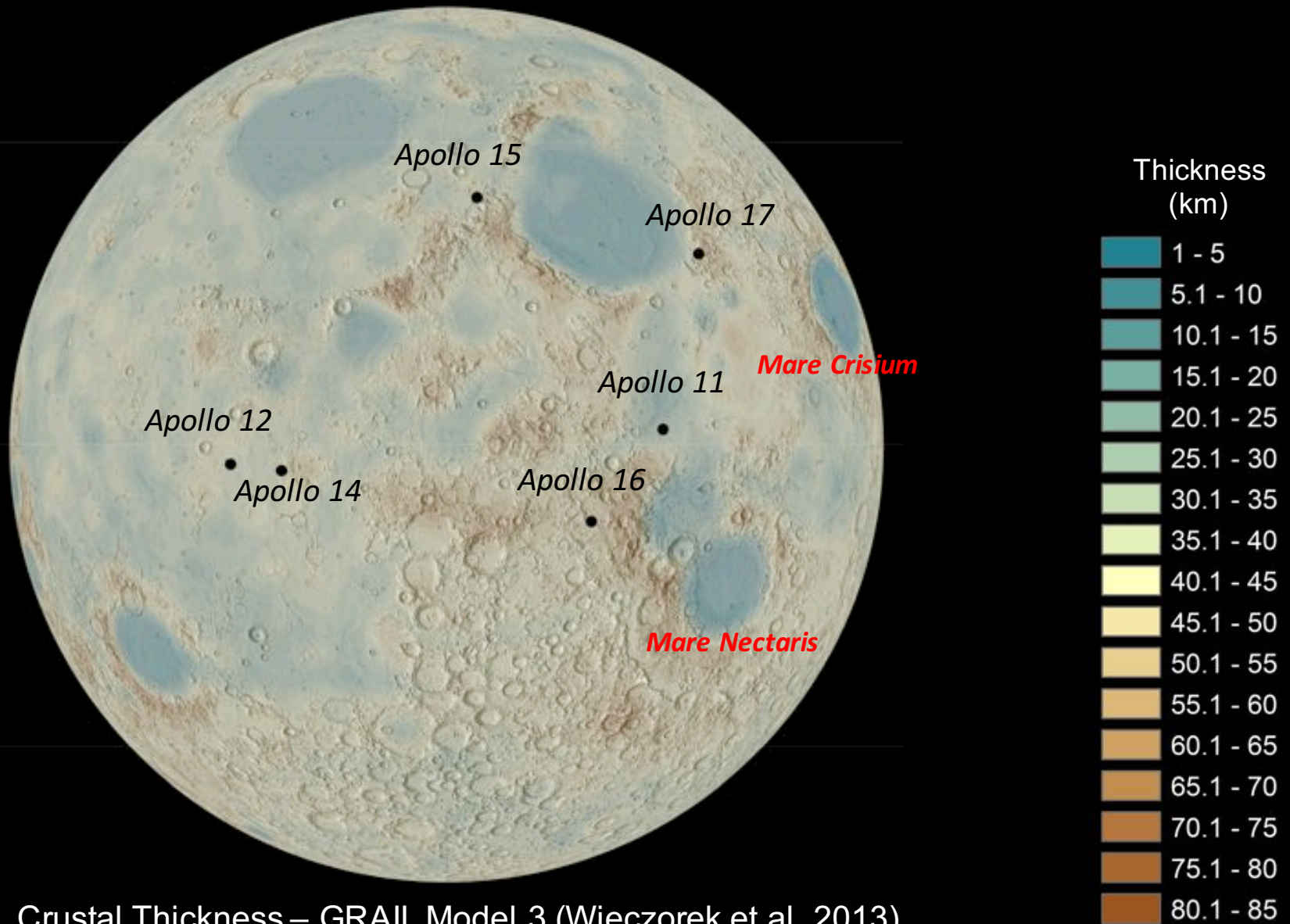
Heat flow at A15 is higher because of the greater concentration of heat-producing elements in the PKT crust?



The heat released from the lunar surface (Q_s) is probably greater than the heat which flows across the crust-mantle boundary (Q_m), because of radiogenic heat production within the crust (i.e., $Q_s > Q_m$). The crust is thought to be more abundant in heat producing elements than the mantle. But we do not really know how the elemental concentrations vary with depth.

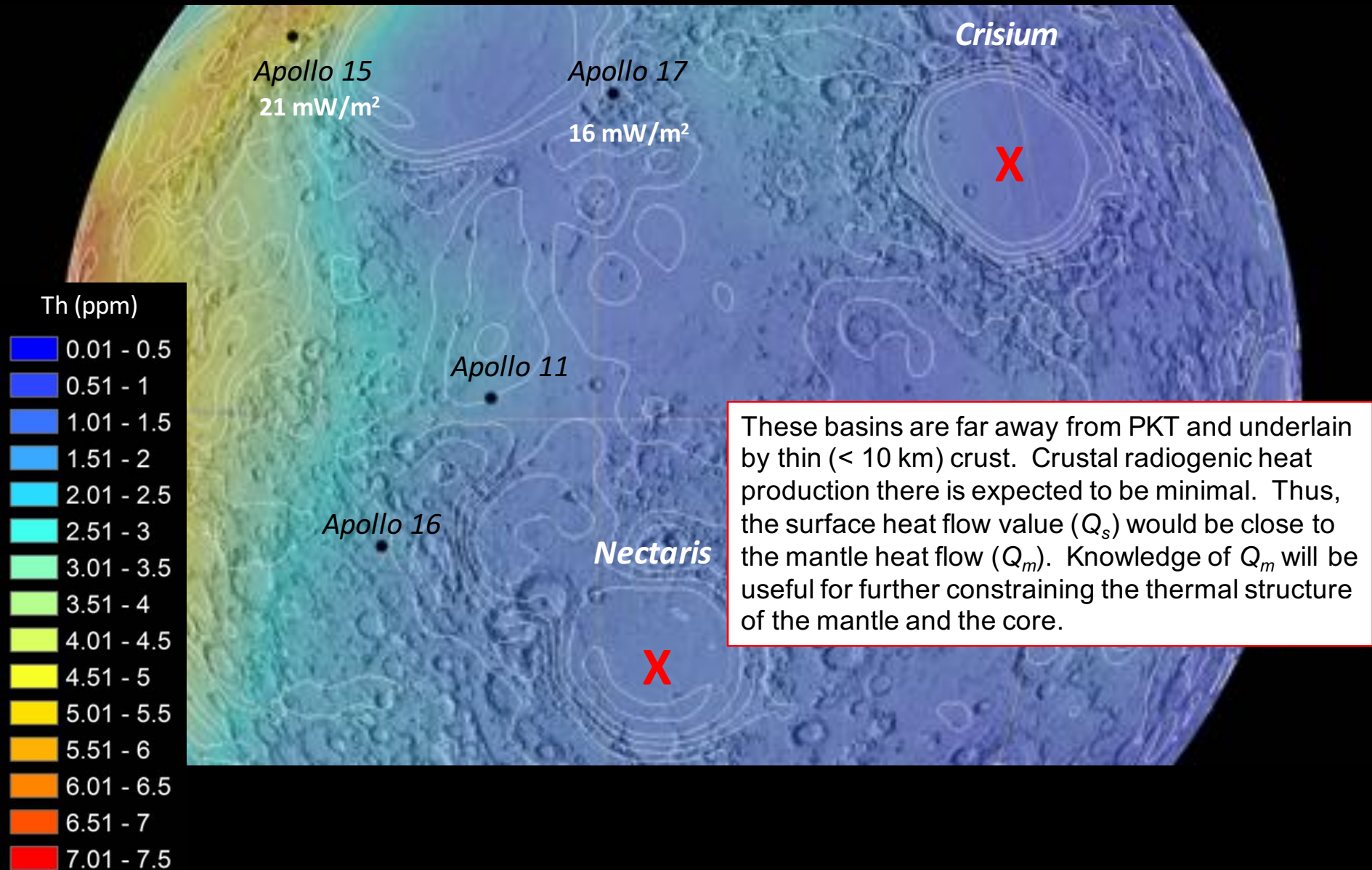


Crustal thickness varies geographically from ~5 to ~80 km. Heat produced radioactively within the crust may also vary with crustal thickness.



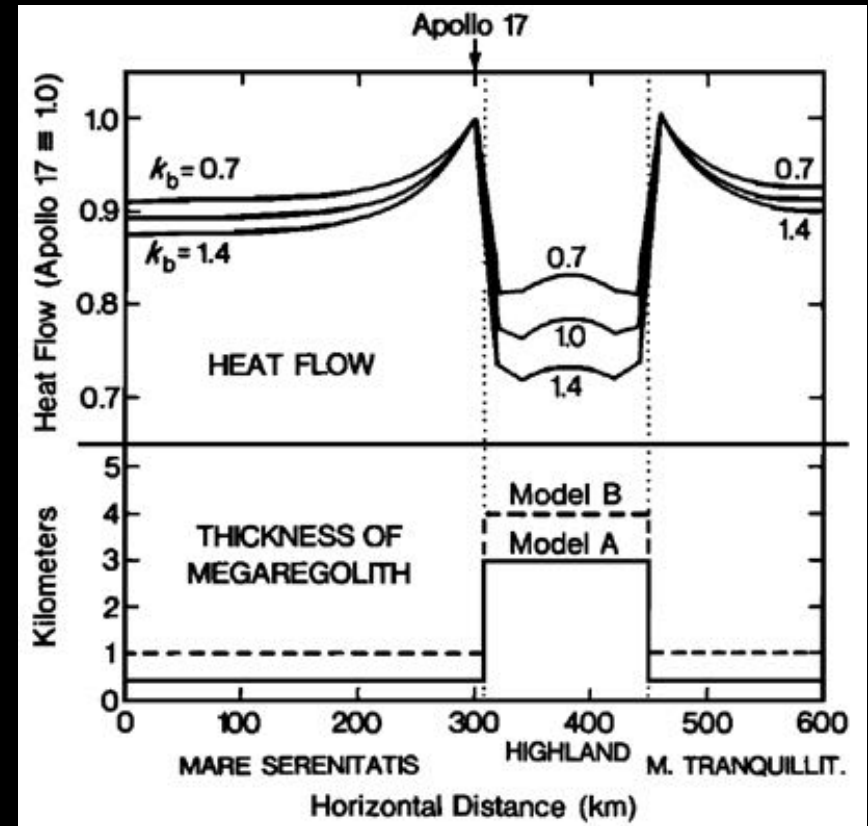
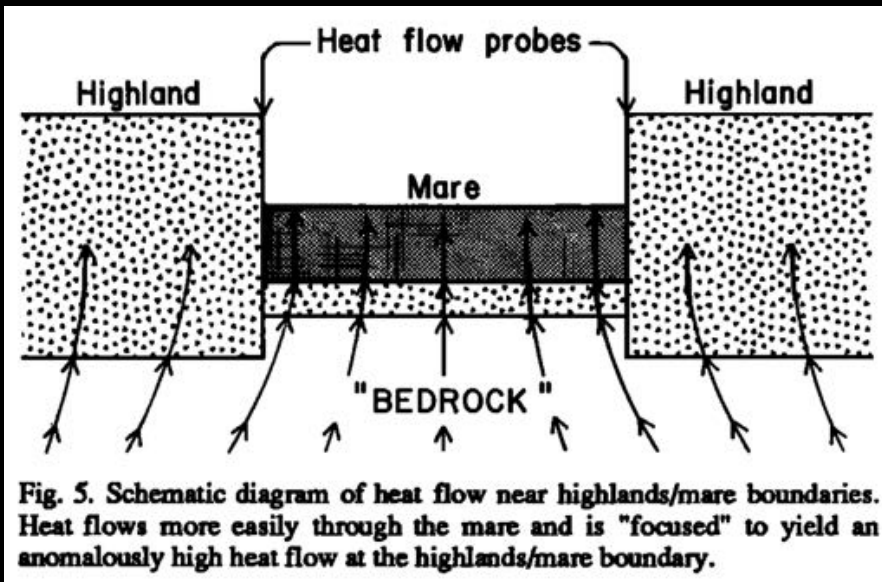
Crustal Thickness – GRAIL Model 3 (Wieczorek et al. 2013)

Central parts of Crisium and Nectaris Recommended for Heat Flow Measurements



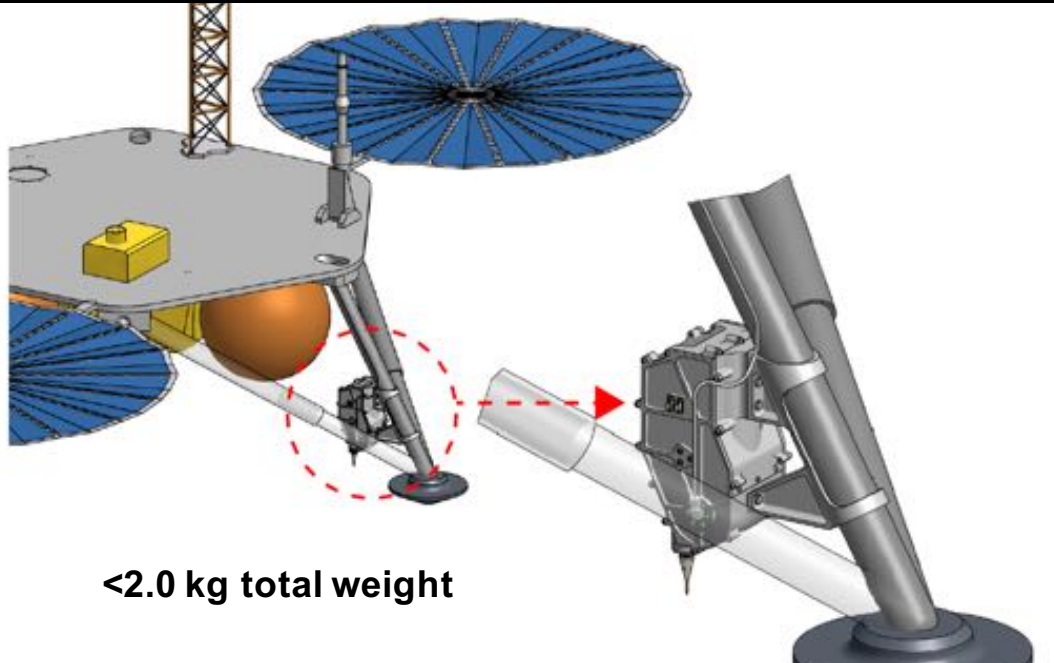
A17 site may not be far enough away from the PKT and may be underlain by Th-rich PKT ejecta (Hagermann and Tanaka, 2007)

Edge of a basin should be avoided. The sharp contrast in lithology and crustal thickness may cause refraction of the heat flow through the crust.

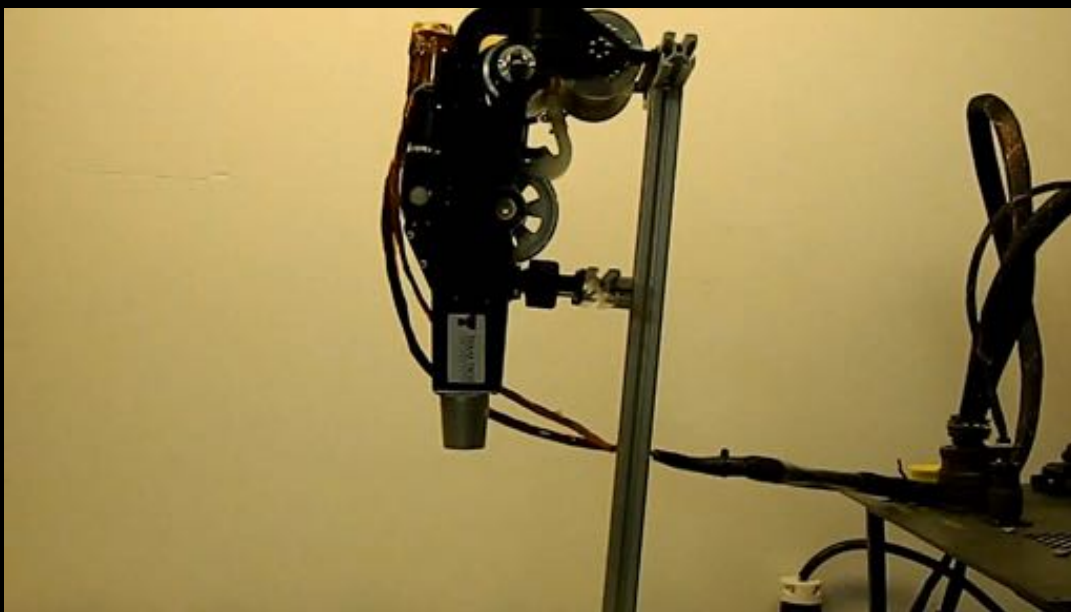
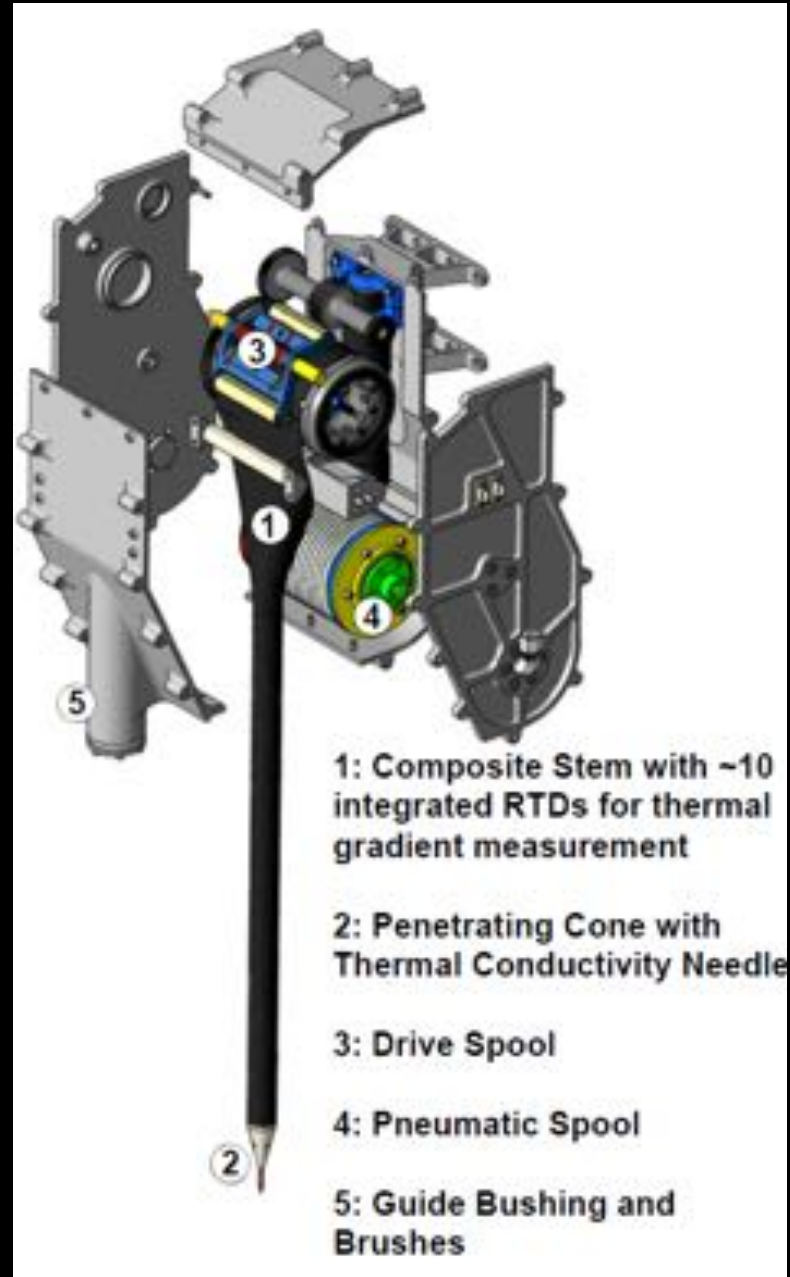


Warren & Rasmussen (1987)

New Lander-based Heat Flow Probe: System Overview



<2.0 kg total weight

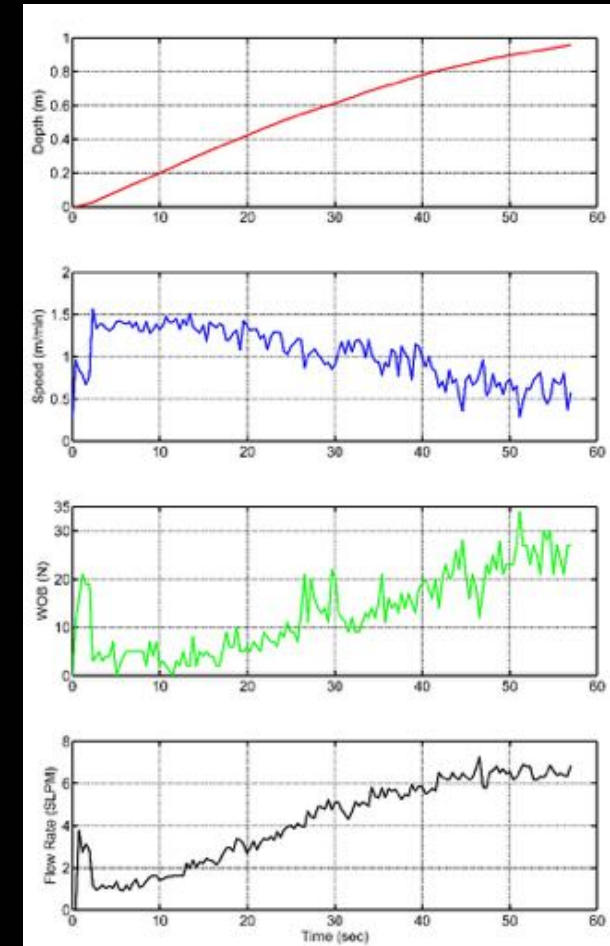


Pneumatic excavation for sensor deployment

Gas jets emitted from the tip of the penetrating cone blow away regolith, while the actuator presses it downward.



1-m excavation test in JSC-1A in a vacuum (4 Torr) chamber



The cone reached 1-m depth in less than a minute, using 5 grams of Ni gas at 400 kPa.

Conclusions

- For additional heat flow measurements, we recommend central locations in major mare basins away from the PKT such as the Crisium and Nectaris basins.
- Heat flow in these basins may closely represent the flow out of the mantle, which is useful for constraining the thermal structure of the deep interior of the Moon.
- Both Crisium and Nectaris are located in the near side, and they have wide, flat basin floors.
- Heat flow measurement does not require sample-return capability, and the heat flow probe can be accommodated into a variety of lander designs.
- Suitable for maiden voyage missions to the Moon.

©JAXA/NHK

This work has been supported by NASA's Science Mission Directorate (LASER 2010, PDART 2014).